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Technical Note

No. 206-5

THE NORMAL PHASE VARIATIONS OF THE 16 kc/s SIGNALS FROM GBR OBSERVED AT COLLEGE, ALASKA

J. H. CRARY AND A. C. MURPHY

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NATIONAL BUREAU OF STANDARDS

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ISSUED September 30, 1965

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J. H. Crary and A. C. Murphy
Central Radio Propagation Laboratory
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Boulder, Colorado

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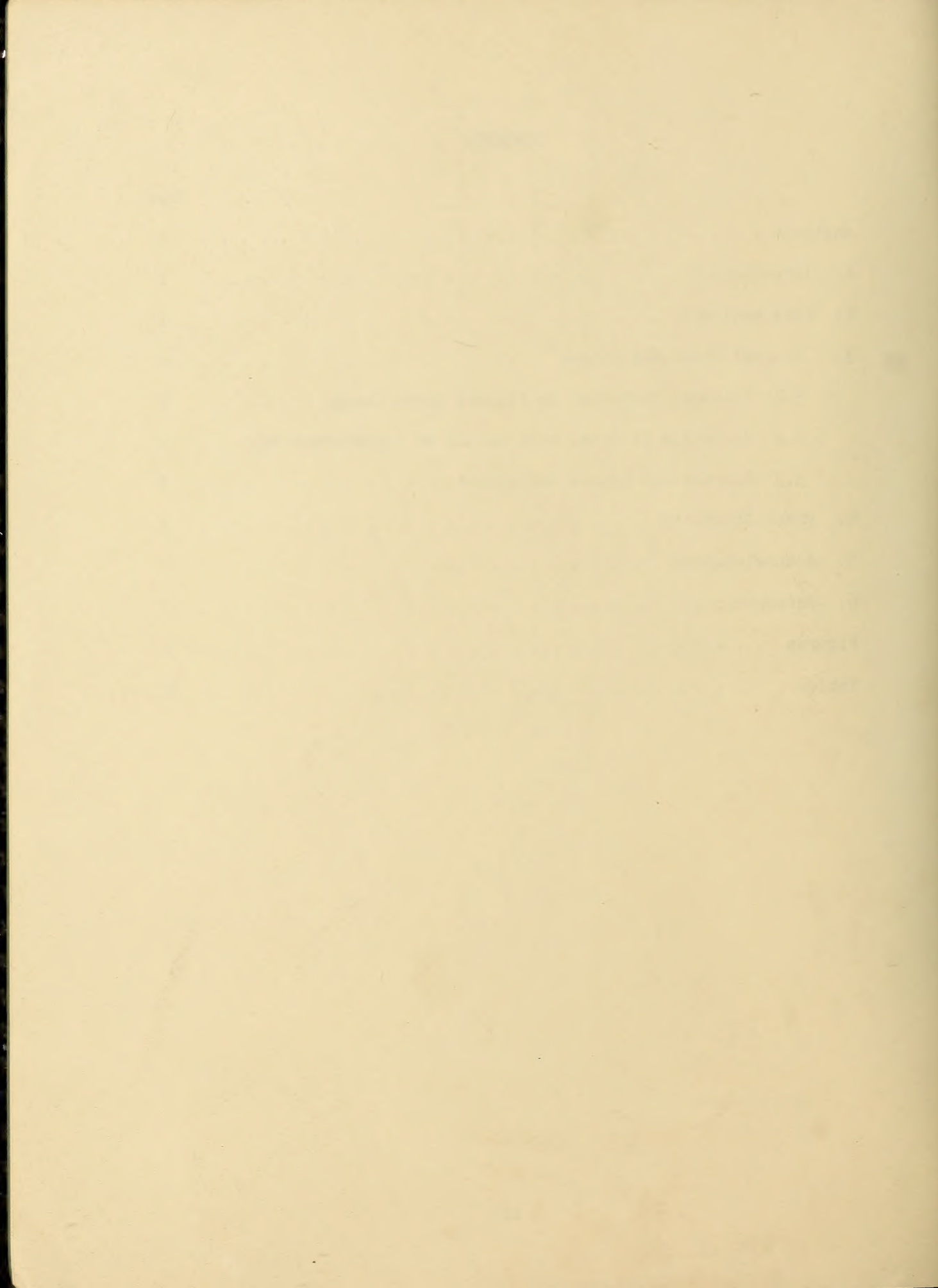
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The Normal Phase Variations of the 16 kc/s Signals
from GBR Observed at College, Alaska, U.S.A.

J. H. Crary and A. C. Murphy

Observations of the normal phase variations of the 16 kc/s signals radiated from Rugby, U.K., and received in College, Alaska, U.S.A., are given in the form of 15-day averages and standard deviations at 5 minute intervals. The relations between the diurnal phase variations and the diurnal variation in the percentage of the path in darkness are shown. The values of the short term phase differences are also given.

Key Words: VLF, phase, normal, diurnal, England-Alaska.

1. Introduction

This is the fifth of a series of reports, each of which summarizes the normal (or undisturbed) behavior of the phase of signals from various VLF transmitters as observed at particular receiving sites. This report deals with the reception at College, Alaska (lat. N $64^{\circ} 51' 36''$, long. W $147^{\circ} 33' 48''$), of 16 kc/s transmission of GBR, Rugby, U.K. (lat. N $52^{\circ} 22' 10''$, long. W $1^{\circ} 11' 15''$), a path length of 6651 km.

The earlier four reports in this series deal with the reception of NBA at Frankfurt, Germany [Brady et al., 1963], Maui, Hawaii [Brady et al., 1964a], Boulder, Colorado [Brady et al., 1964b] and College, Alaska [Crary and Murphy, 1965].

It is the purpose of these reports merely to present the reduced phase data, with a minimum of discussion. The data in these reports will be used in subsequent papers, each of which will deal with a specific aspect of the data on all the paths.

2. Data Analysis

All the phase data used in these reports have been taken, reduced, and presented in a uniform manner as described in the first of the series [Brady et al., 1963]. Thus tables 1-12 contain monthly phase averages (AVER) at 5 minute intervals, standard deviations (SDV), the number of observations (NO) used in obtaining these quantities, the quiet average (QAV), which is the average after values more than one standard deviation from AVER are discarded, and the number (NO) of values used in QAV. (A fuller description of these tables is given in the first note of this series).

3. Diurnal Phase Variations

The monthly mean phase changes and standard deviations for 1962, taken from tables 1-12, are plotted in figures 1 and 2. The average diurnal phase change for 1962 is 125° . Because of the annual change in the diurnal variation of illumination, this value is difficult to interpret. The maximum diurnal phase change of 315° during the 15-day periods shown in table 13 occurs from September 25 to October 5. During this period the illumination should be nearly symmetrical about the equator and should change from zero to 100%. According to the mode theory of VLF propagation [Wait, 1962], this phase change corresponds to a change in the effective height of the ionosphere along the whole path of 20.8 km (assuming that the ionosphere is sharply bounded and that the mean of the daytime and nighttime heights is 80 km).

3.1 Seasonal Variation in Diurnal Phase Change

The mean diurnal phase change for each 15-day period is listed in table 13. The seasonal variation in diurnal phase change is plotted in figure 15 versus the percentage diurnal change in illumination along the path. The approximately linear relationship between the relative phase change and the change in illumination is apparent from this figure although a large amount of scatter is present, especially when the illumination is changing rapidly. Because of this large amount of scatter and the rapid variations in illumination that occur along this path, it was not deemed worthwhile to perform a Fourier analysis of the seasonal variation in the diurnal height change.

3.2 Variation of Phase with Amount of Illuminated Path

The monthly average phase variation shown in figures 1 and 2 shows typical superficial dependence on the length of path which is in daylight [Crombie et al., 1958; Pierce, 1957]. A more detailed examination of the relationship is given by plotting the diurnal phase changes at sunrise and sunset, together with variation in the length of illuminated path (at appropriate heights) at these times. This has been done in figures 3-14, which show the sunrise and sunset variations for each 15-day period for 1962. The figures have been drawn so that the maximum diurnal phase variation of 315° fits the full "percent darkness" scale in each case.

The calculations of the length of illuminated path were made in the way described by Brady and Crombie [1964] and Crary [1965]. It is assumed in these calculations that the screening height of the earth's atmosphere is 30 km. Sunrise or sunset at the heights of 0 and 80 km are thus equivalent to solar zenith angles of 90° and 97° .

3.3 Sunrise and Sunset Variations

Figures 3-14 show that the smooth diurnal phase change follows fairly closely the percentage of the path in darkness. On a high latitude path, such as this one, the sunrise and sunset times change very rapidly at most times of the year. It is therefore difficult to make generalizations about the details of the time of the phase changes relative to the percentage of the path in darkness. In general the phase is bracketed fairly well by the ground and 80 km (or alternatively $\chi = 90$ or 97°) curves.

4. Phase Stability

It was pointed out in the first paper of this series that both day-to-day phase stabilities and the phase variations over periods of time up to an hour or so were of interest. Typical values for the path being considered have been given in each paper.

The day-to-day standard deviations of phase observed at College are given at 5 minute intervals for each month of 1962 in tables 1-12, and are also plotted in figures 1 and 2. Since this is a high latitude path, the diurnal and seasonal variations in illumination are very rapid. The time intervals in which maximum darkness or daylight occurs can be very short in summer or winter, respectively; daylight or darkness does not always occur under these conditions.

During the hours when the path is completely daylit, the day-to-day standard deviations have a value of about 10° without any seasonal trend being apparent. When the path is dark, the day-to-day standard deviations vary between about 10° and 30° , again without a perceptible seasonal variation. A change of 1° in phase corresponds to a calculated change in the effective height of the ionosphere of 0.065 km along the entire path. If these observed phase changes are considered to occur along the whole path, they are equivalent to effective height changes of 0.7 km during the day and 0.7 to 2.1 km during the night.

The method of obtaining the short term phase variations has been described in the first of this series [Brady et al., 1963]. Table 14 contains the rms phase differences calculated in this way for intervals of 10-90 minutes (T). The data are given for both daytime and nighttime conditions during each month of 1962. As noted in the other papers of this series, the rms phase differences increase as the time interval T increases, particularly when T is small. During the summer months there is also a general tendency for the magnitude of the fluctuations for small T to be greater at night than during the day. The reverse situation tends to be true during the winter. There is a tendency for these characteristics to also be true for large T but there are exceptions to this. The difference in magnitude between the day and night values tends to be greater in the summer and for large values of T.

5. Acknowledgment

The observations at College, Alaska, were obtained by Dr. H. F. Bates and Mr. Paul Albee of the Geophysical Institute at the University of Alaska. The work was supported under Contract CST-7338 of the National Bureau of Standards from the Advanced Research Projects Agency, Washington, D. C., under Order No. 183, which also supported the work at NBS.

6. References

- Brady, A. H., and D. D. Crombie (1964), Calculation of sunrise and sunset times at ionospheric heights along a great circle path, NBS Tech. Note No. 209.
- Brady, A. H., A. C. Murphy, and D. D. Crombie (1963), The normal phase variations of the 18 kc/s signals from NBA observed at Frankfurt, Germany, NBS Tech. Note No. 206-1.
- Brady, A. H., A. C. Murphy, and D. D. Crombie (1964a), The normal phase variations of the 18 kc/s signals from NBA observed at Maui, Hawaii, NBS Tech. Note No. 206-2.
- Brady, A. H., A. C. Murphy, and D. D. Crombie (1964b), The normal phase variations of the 18 kc/s signals from NBA observed at Boulder, Colorado, U.S.A., NBS Tech. Note No. 206-3.
- Crory, J. H. (1965), Extension of programs for calculations of great circle paths and sunrise-sunset times, NBS Tech. Note No. 303.
- Crory, J. H. and A. C. Murphy (1965), The normal phase variations of the 18 kc/s signals from NBA observed at College, Alaska, U.S.A., NBS Tech. Note No. 206-4 (to be published).
- Crombie, D. D., A. H. Allan, and M. Newman (May 1958), Phase variations of the 16 kc/s transmission from Rugby as received in New Zealand, Proc. IEE 105B, 301-304.
- Pierce, J. A. (1957), Intercontinental frequency comparisons by VLF radio transmission, Proc. IRE 45, 794-803.
- Wait, J. R. (1962), Electromagnetic waves in stratified media, Pergamon Press, London.

GBR (16 kc/s, RUGBY, ENGLAND) TO COLLEGE, ALASKA
AVERAGE PHASE FOR JANUARY - MARCH AND OCTOBER-DECEMBER 1962

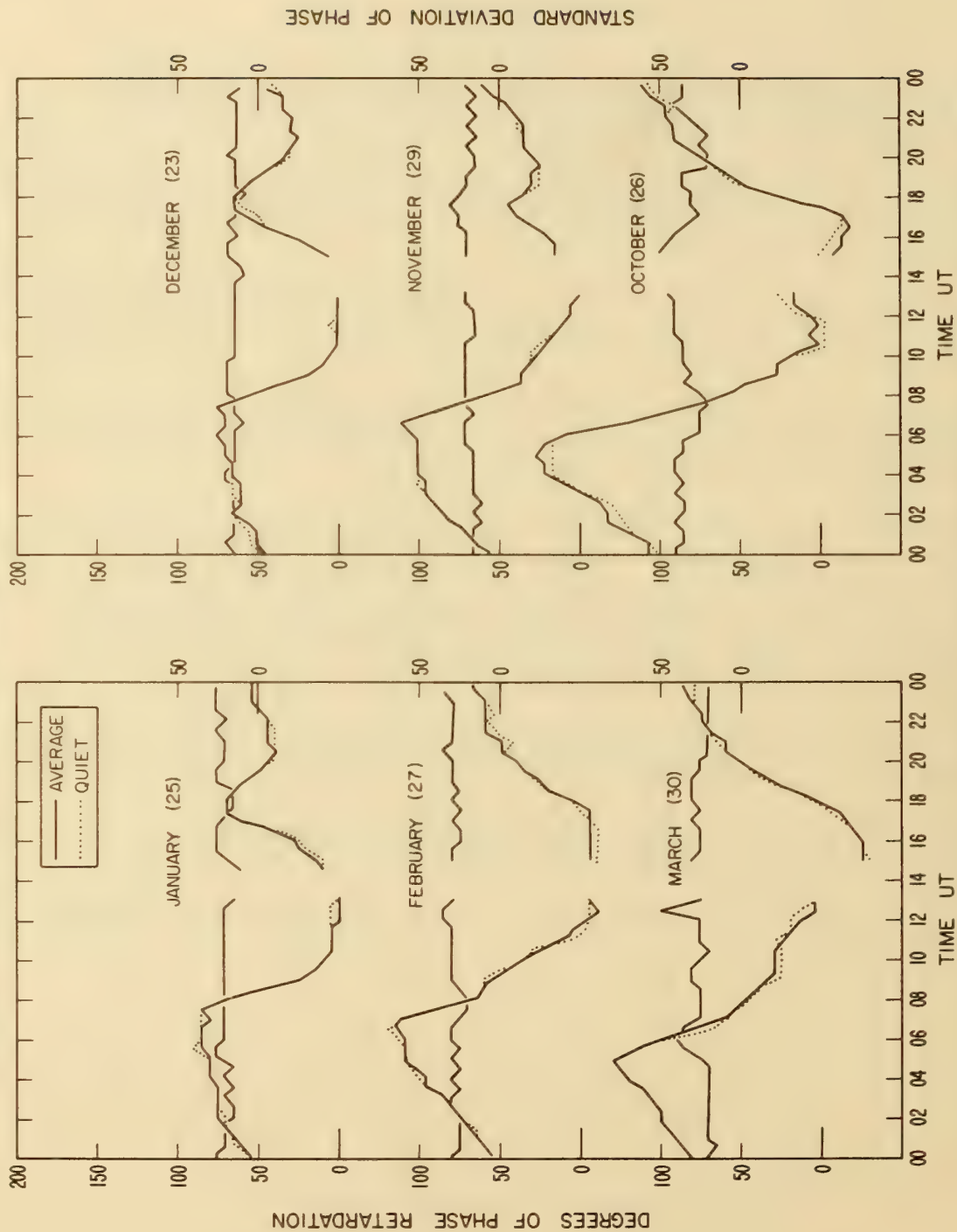


Figure 1. Mean phase variations and standard deviations in degrees from GBR Rugby to College, Alaska, January-March and October-December 1962.

GBR (16 kc/s, RUGBY, ENGLAND) TO COLLEGE, ALASKA
AVERAGE PHASE FOR APRIL - JUNE AND JULY - SEPTEMBER 1962

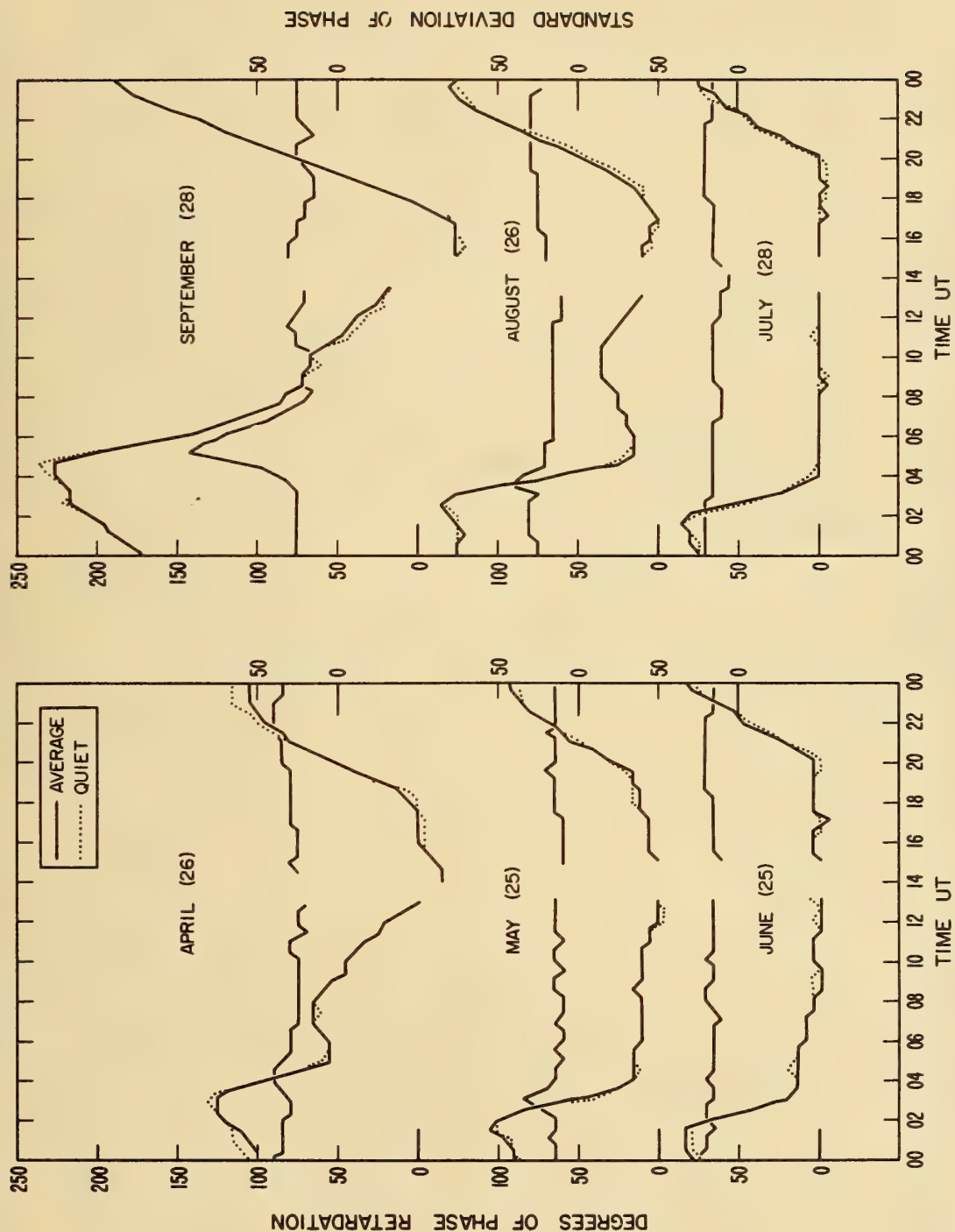


Figure 2 Mean phase variations and standard deviations in degrees for GBR Rugby to College, Alaska, April-June and July-September 1962.

DIURNAL VARIATION AND PERCENTAGE OF DARKNESS ON GBR-COLLEGE PATH

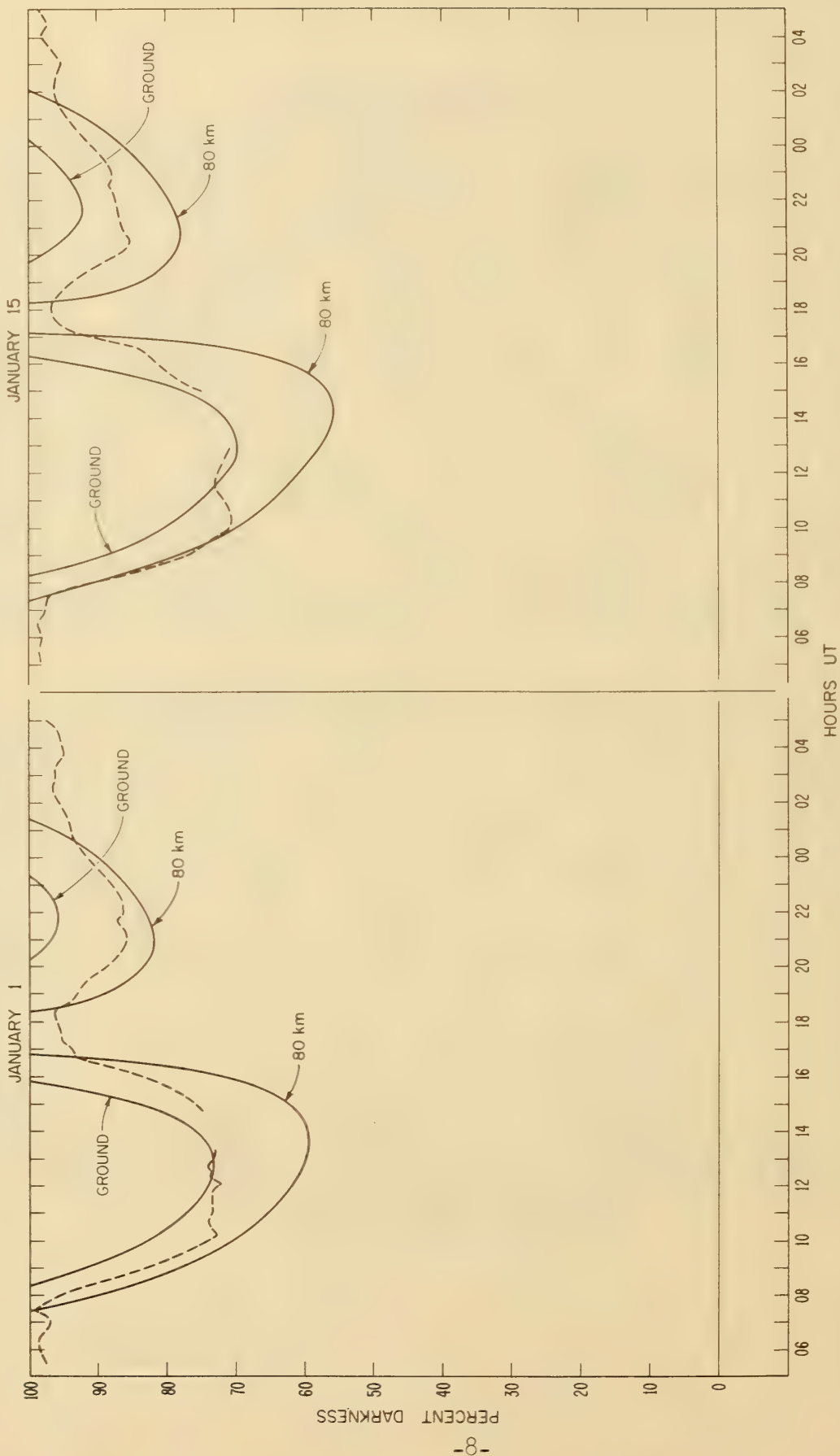


Figure 3. Mean phase variation (dotted lines) and percentage of darkness (solid lines) on GBR, Rugby to College, Alaska, path for 15 day intervals centered on January 1 and 15, 1962. (Note: The ordinate also gives the percentage of the yearly maximum diurnal phase variation which has occurred.)

DIURNAL VARIATION AND PERCENTAGE OF DARKNESS ON GBR-COLLEGE PATH

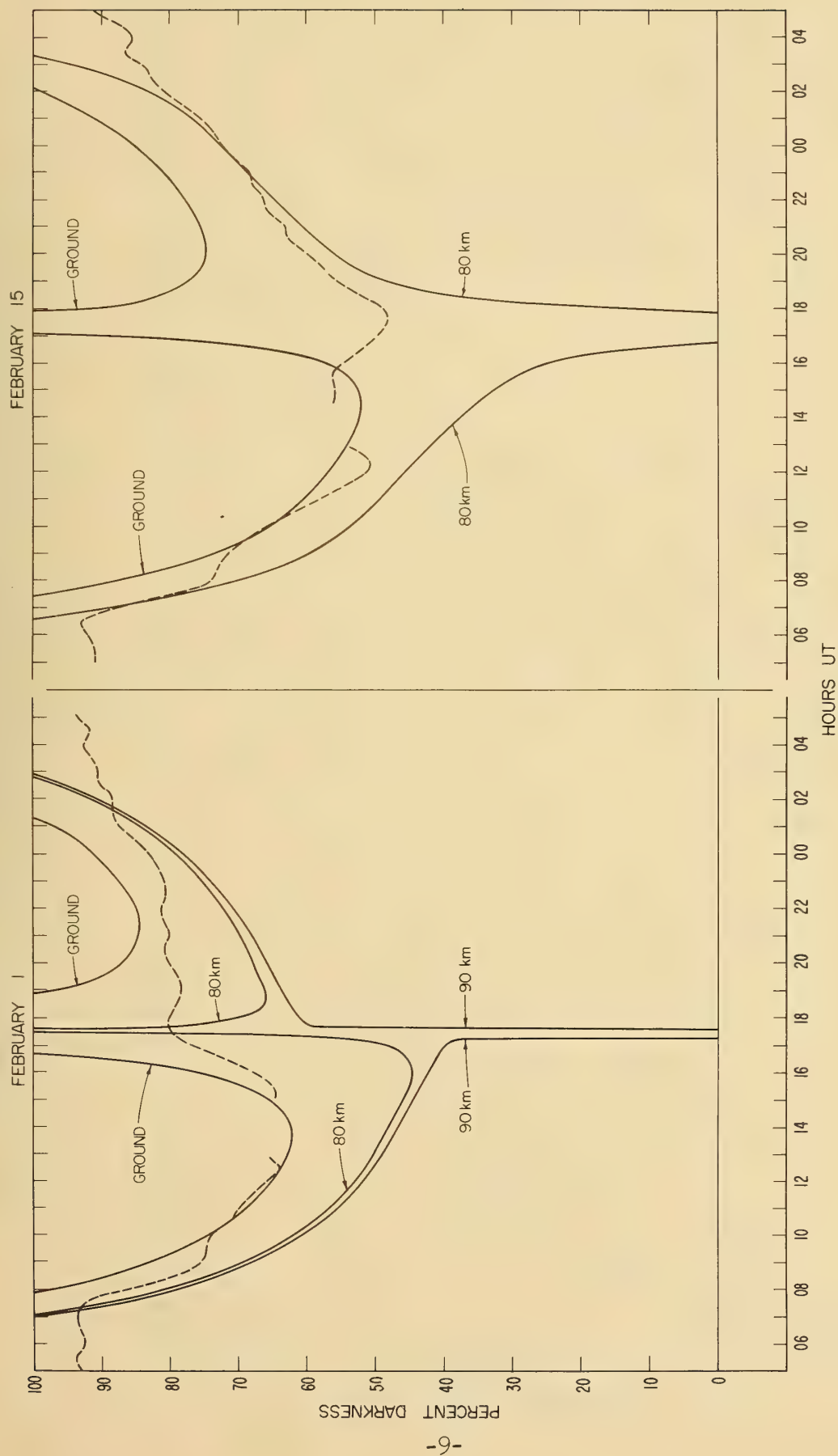


Figure 4. Mean phase variation (dotted lines) and percentage of darkness (solid lines) on GBR, Rugby to College, Alaska, path for 15 day intervals centered on February 1 and 15, 1962. (Note: The ordinate also gives the percentage of the yearly maximum diurnal phase variation which has occurred.)

DIURNAL VARIATION AND PERCENTAGE OF DARKNESS ON GBR-COLLEGE PATH

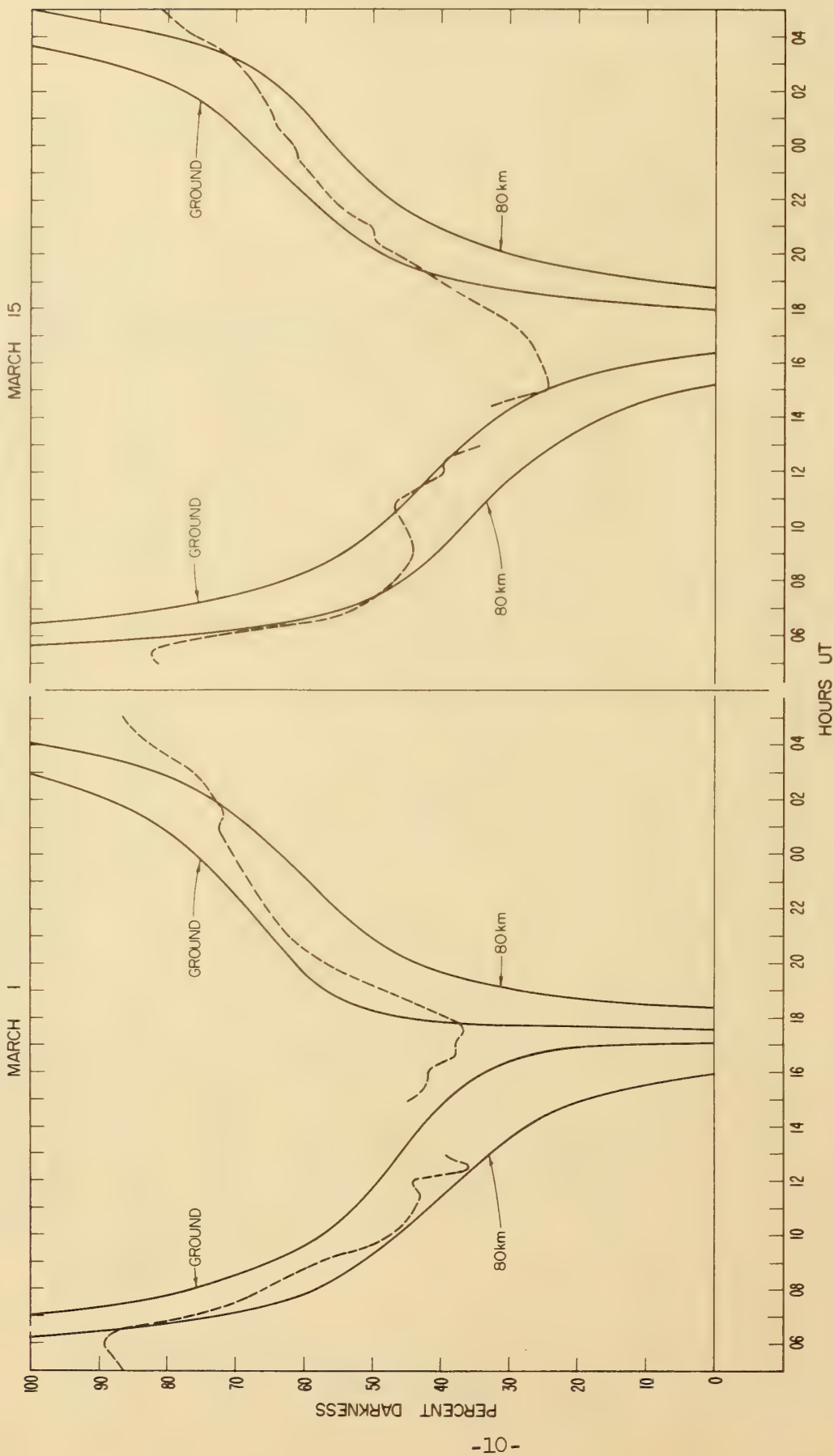


Figure 5. Mean phase variation (dotted lines) and percentage of darkness (solid lines) on GBR, Rugby to College, Alaska, path for 15 day intervals centered on March 1 and 15, 1962. (Note: The ordinate also gives the percentage of the yearly maximum diurnal phase variation which has occurred.)

DIURNAL VARIATION AND PERCENTAGE OF DARKNESS ON GBR-COLLEGE PATH

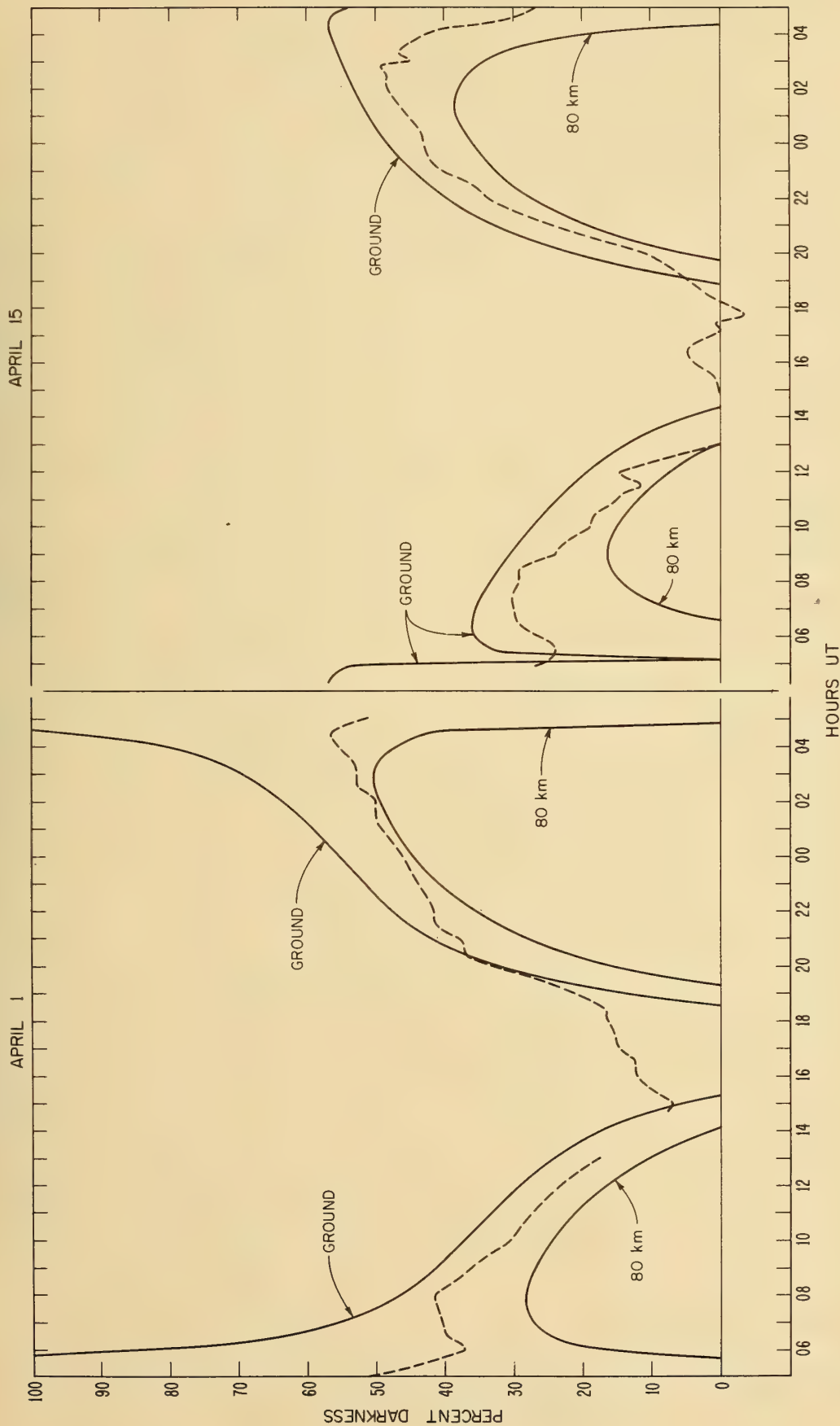


Figure 6. Mean phase variation (dotted lines) and percentage of darkness (solid lines) on GBR, Rugby to College, Alaska, path for 15 day intervals centered on April 1 and 15, 1962. (Note: The ordinate also gives the percentage of the yearly maximum diurnal phase variation which has occurred.)

DIURNAL VARIATION AND PERCENTAGE OF DARKNESS ON GBR-COLLEGE PATH

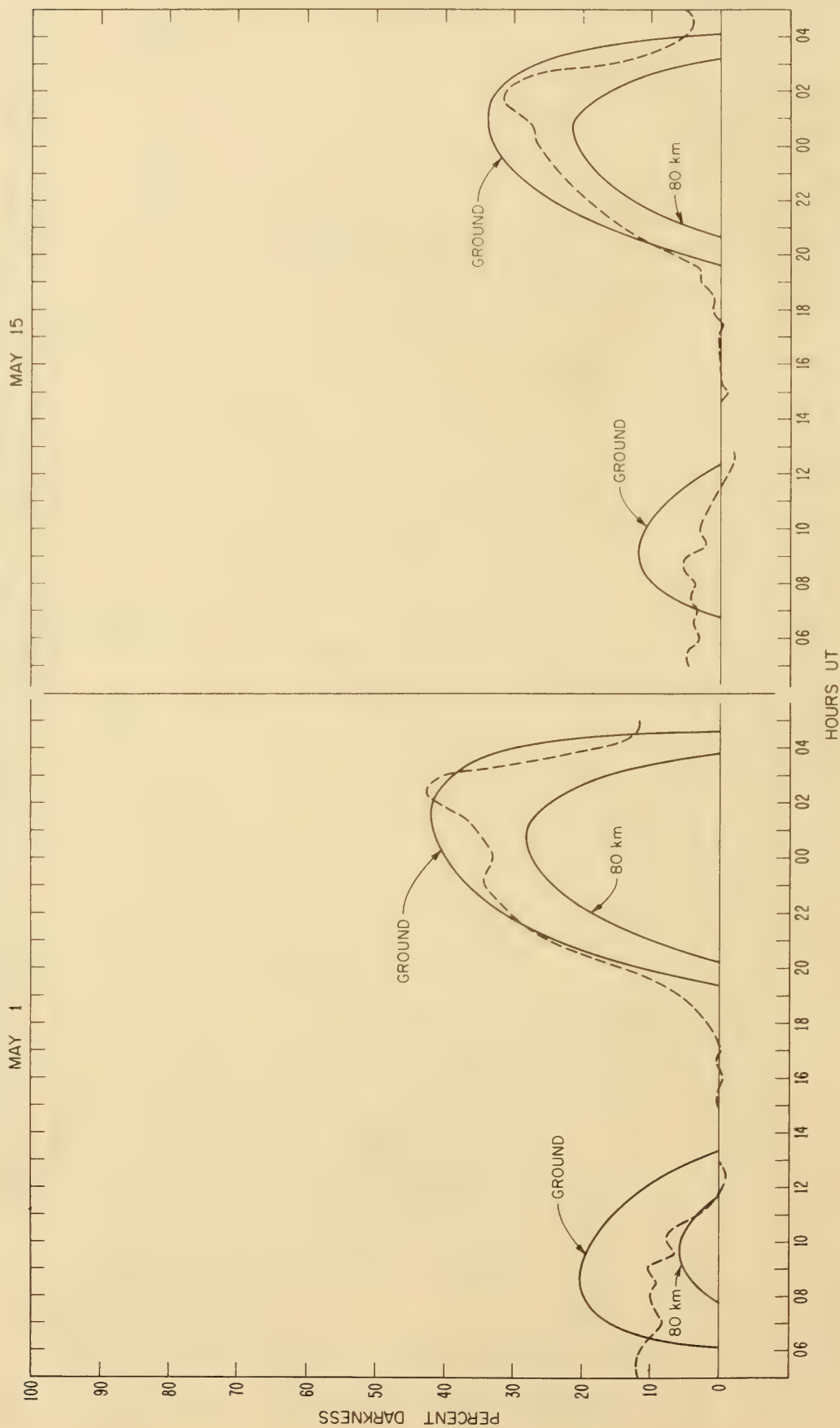


Figure 7. Mean phase variation (dotted lines) and percentage of darkness (solid lines) on GBR, Rugby to College, Alaska, path for 15 day intervals centered on May 1 and 15, 1962. (Note: The ordinate also gives the percentage of the yearly maximum diurnal phase variations which has occurred.)

DIURNAL VARIATION AND PERCENTAGE OF DARKNESS ON GBR-COLLEGE PATH

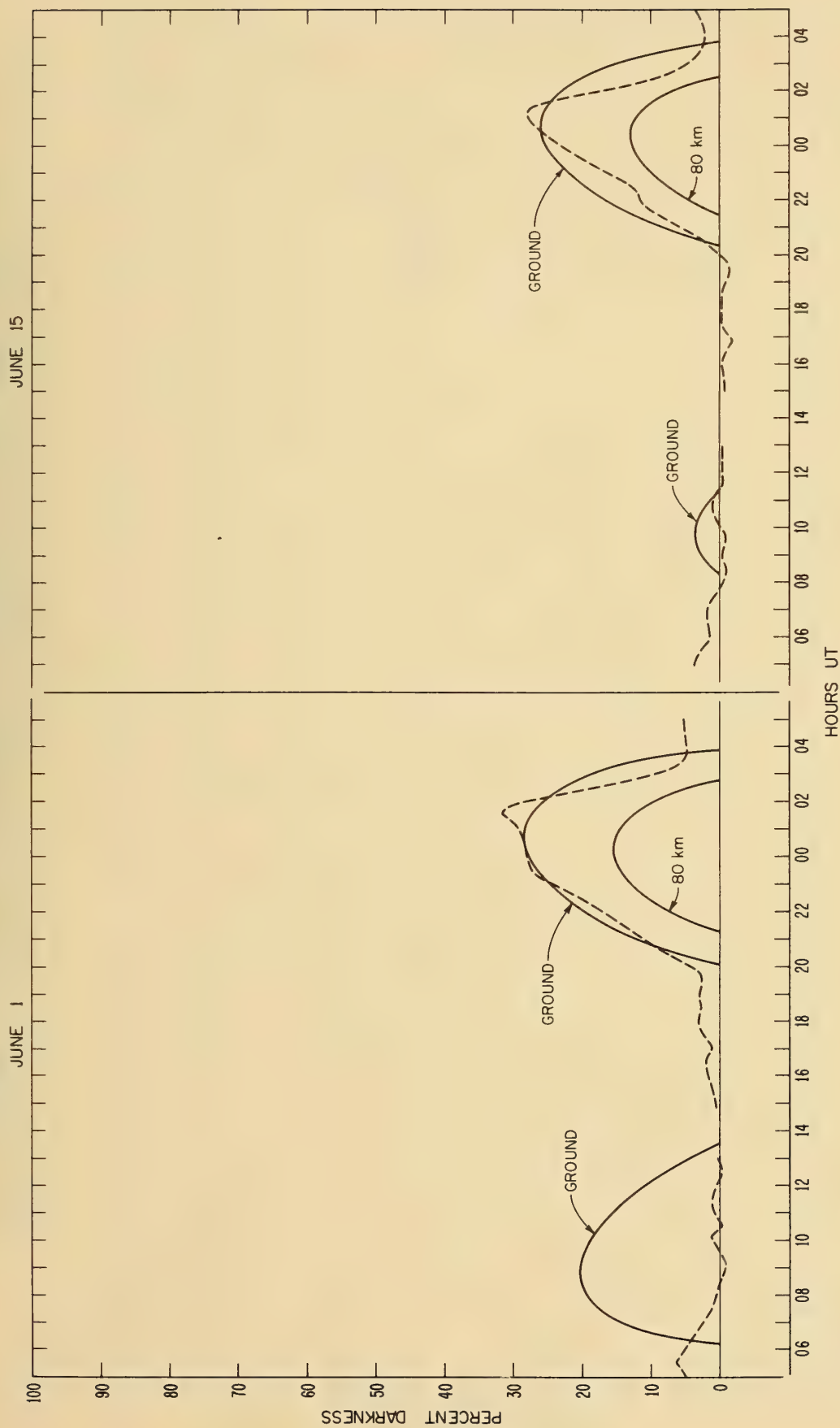


Figure 8. Mean phase variation (dotted lines) and percentage of darkness (solid lines) on GBR, Rugby to College, Alaska, path for 15 day intervals centered on June 1 and 15, 1962. (Note: The ordinate also gives the percentage of the yearly maximum diurnal phase variation which has occurred.)

DIURNAL VARIATION AND PERCENTAGE OF DARKNESS ON GBR-COLLEGE PATH

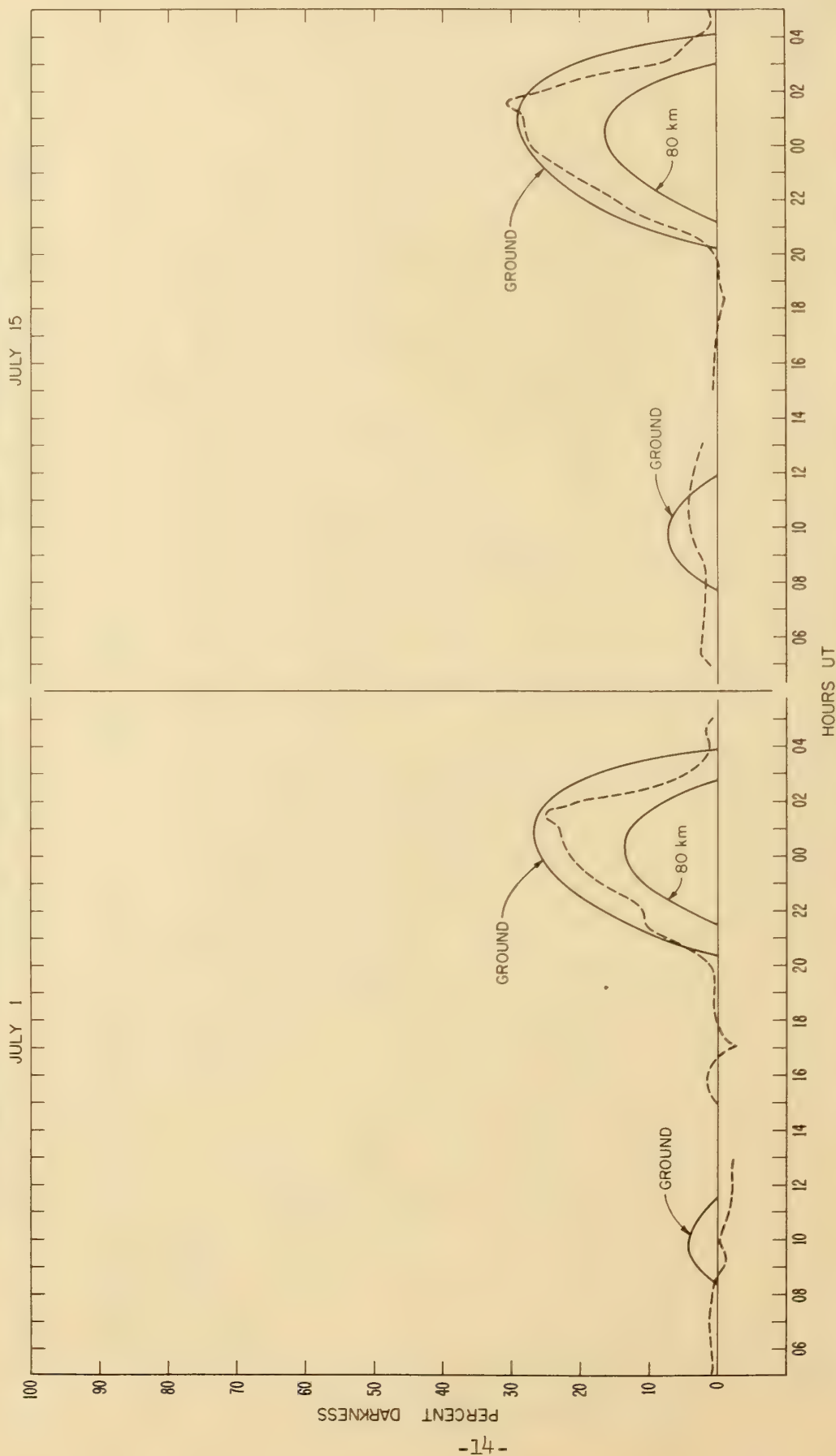


Figure 9. Mean phase variation (dotted lines) and percentage of darkness (solid lines) on GBR, Rugby to College, Alaska, path for 15 day intervals centered on July 1 and 15, 1962. (Note: The ordinate also gives the percentage of the yearly maximum diurnal phase variation which has occurred.)

DIURNAL VARIATION AND PERCENTAGE OF DARKNESS ON GBR-COLLEGE PATH

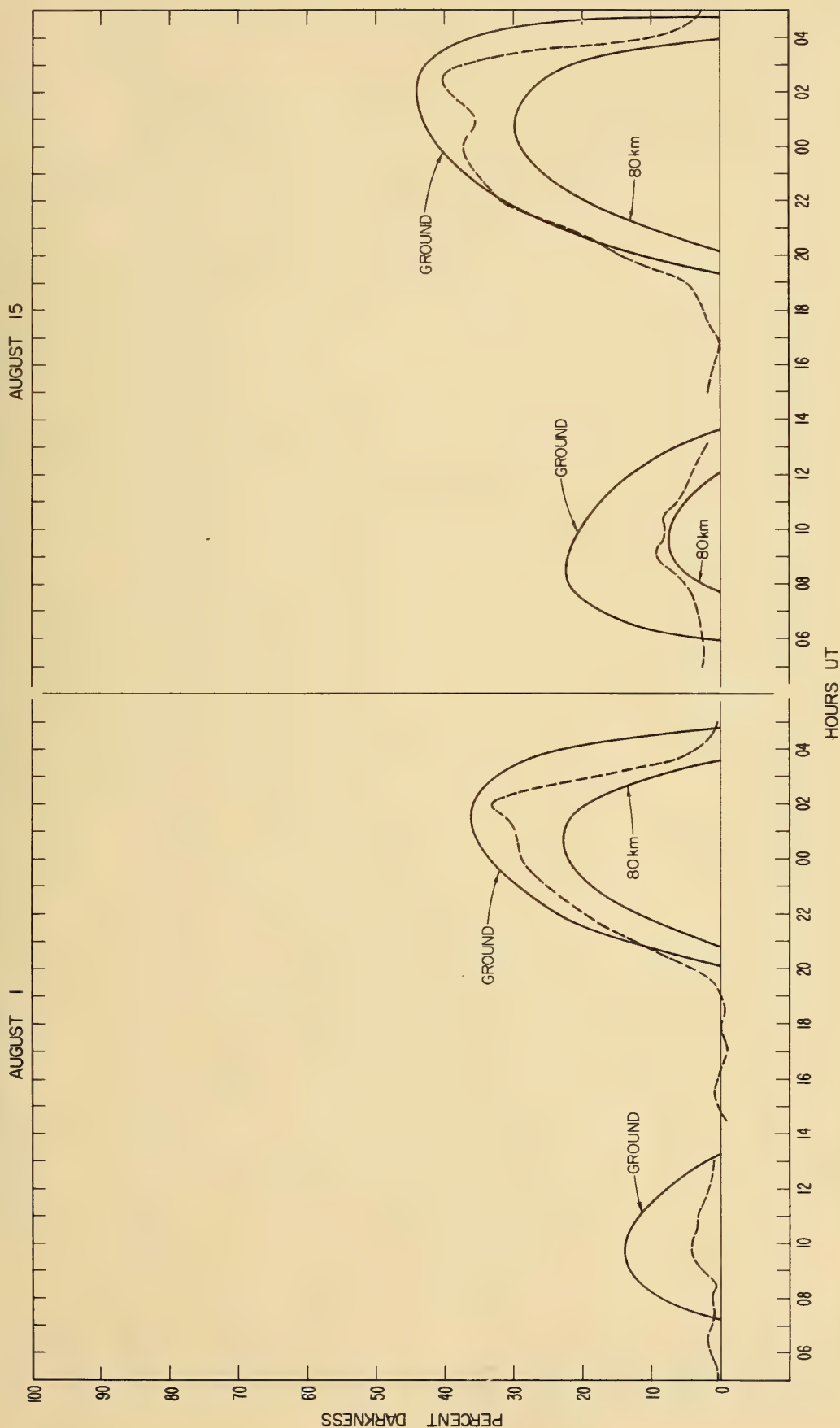


Figure 10. Mean phase variation (dotted lines) and percentage of darkness (solid lines) on GBR, Rugby to College, Alaska, path for 15 day intervals centered on August 1 and 15, 1962.
(Note: The ordinate also gives the percentage of the yearly maximum diurnal phase variation which has occurred.)

DIURNAL VARIATION AND PERCENTAGE OF DARKNESS ON GBR-COLLEGE PATH

SEPTEMBER 15

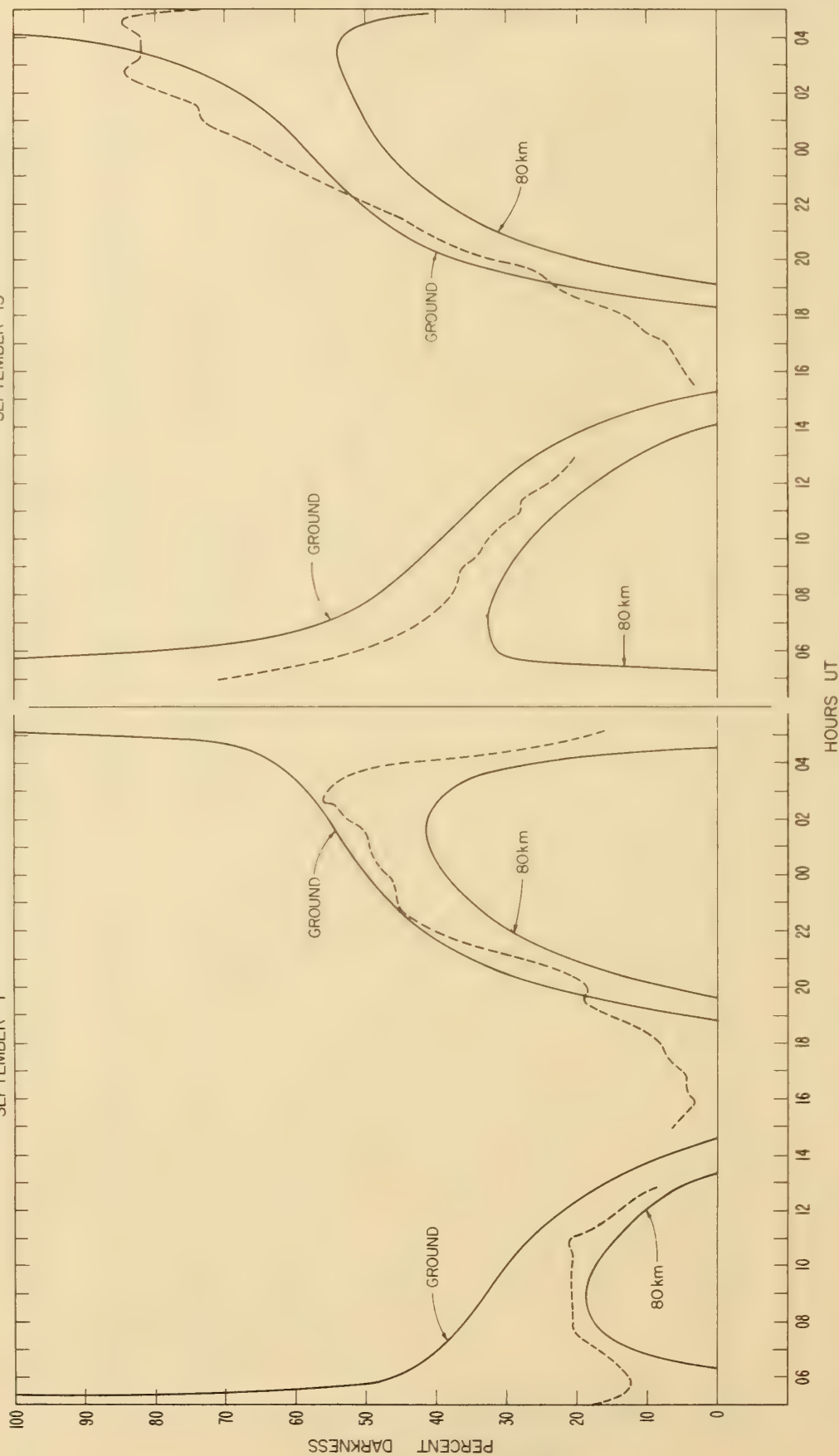


Figure 11. Mean phase variation (dotted lines) and percentage of darkness (solid lines) on GBR, Rugby to College, Alaska, path for 15 day intervals centered on September 1 and 15, 1962. (Note: The ordinate also gives the percentage of the yearly maximum diurnal phase variation which has occurred.)

DIURNAL VARIATION AND PERCENTAGE OF DARKNESS ON GBR-COLLEGE PATH

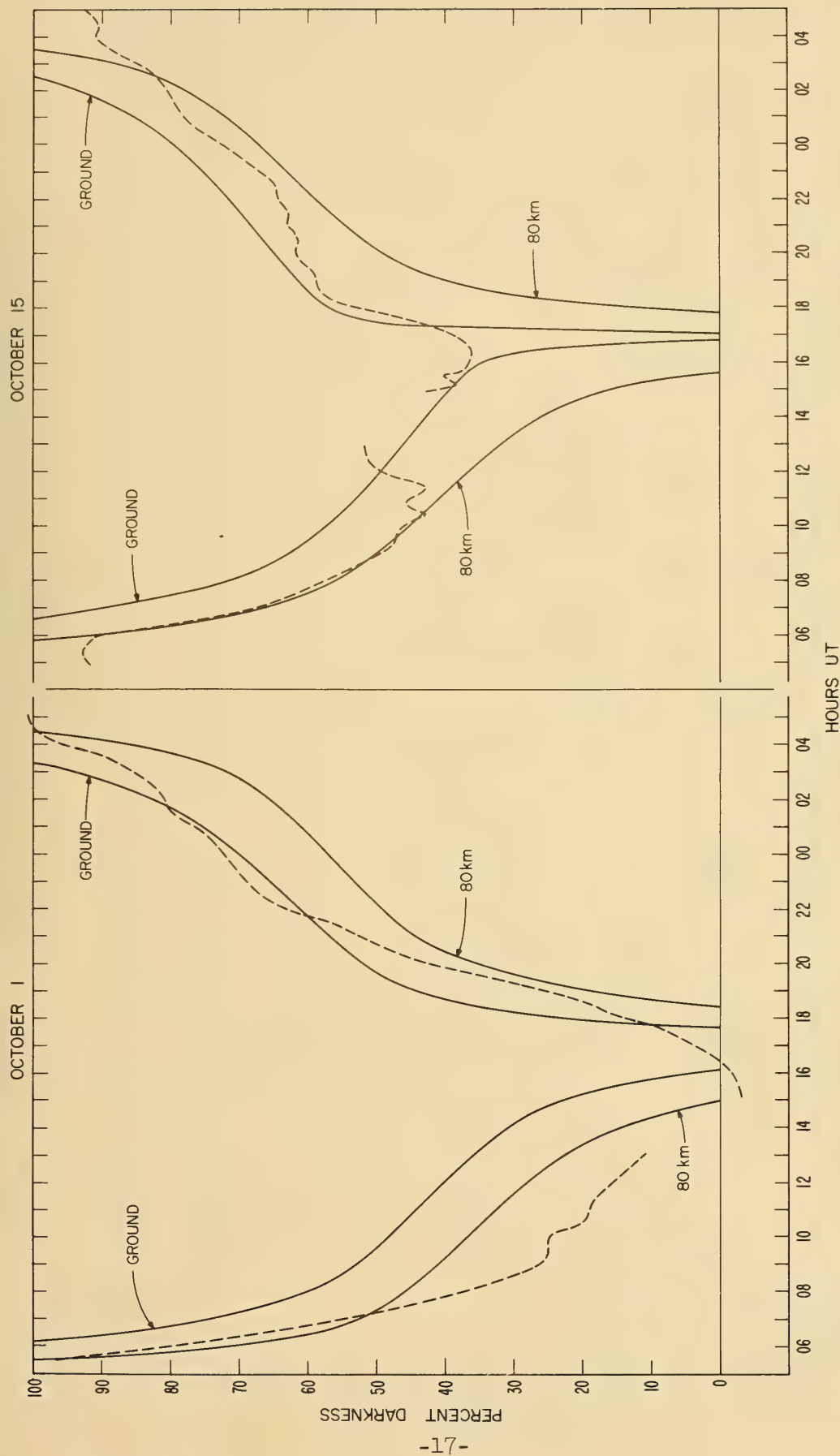


Figure 12. Mean phase variation (dotted lines) and percentage of darkness (solid lines) on GBR, Rugby to College, Alaska, path for 15 day intervals centered on October 1 and 15, 1962. (Note: The ordinate also gives the percentage of the yearly maximum diurnal phase variation which has occurred.)

DIURNAL VARIATION AND PERCENTAGE OF DARKNESS ON GBR-COLLEGE PATH

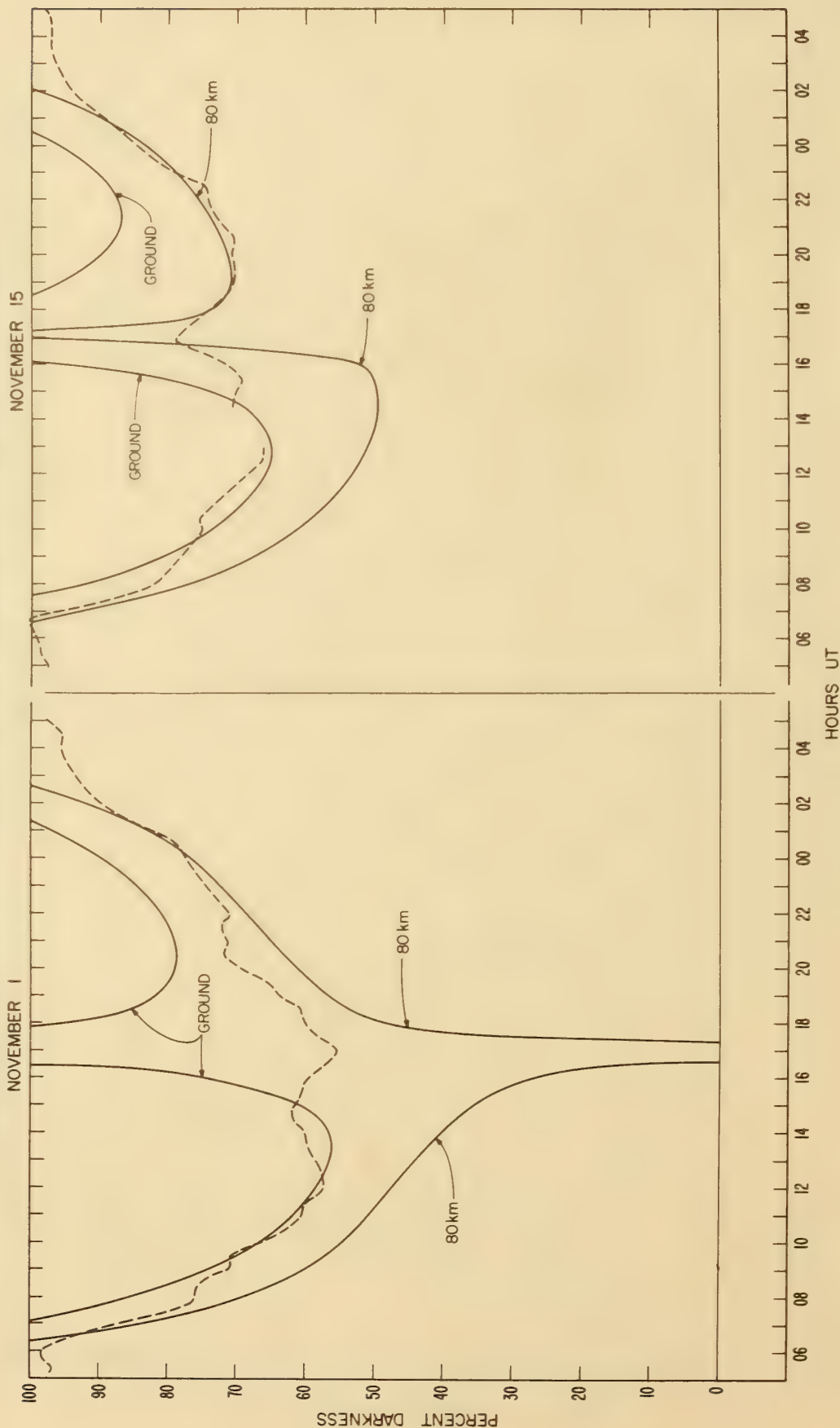


Figure 13. Mean phase variation (dotted lines) and percentage of darkness (solid lines) on GBR, Rugby to College, Alaska, path for 15 day intervals centered on November 1 and 15, 1962. (Note: The ordinate also gives the percentage of the yearly maximum diurnal phase variation which has occurred.)

DIURNAL VARIATION AND PERCENTAGE OF DARKNESS ON GBR-COLLEGE PATH



Figure 14. Mean phase variation (dotted lines) and percentage of darkness (solid lines) on GBR, Rugby to College, Alaska, path for 15 day intervals centered on December 1 and 15, 1962. (Note: The ordinate also gives the percentage of the yearly maximum diurnal phase variation which has occurred.)

CHANGE IN DIURNAL PHASE VARIATION VERSUS CHANGE IN PATH ILLUMINATION

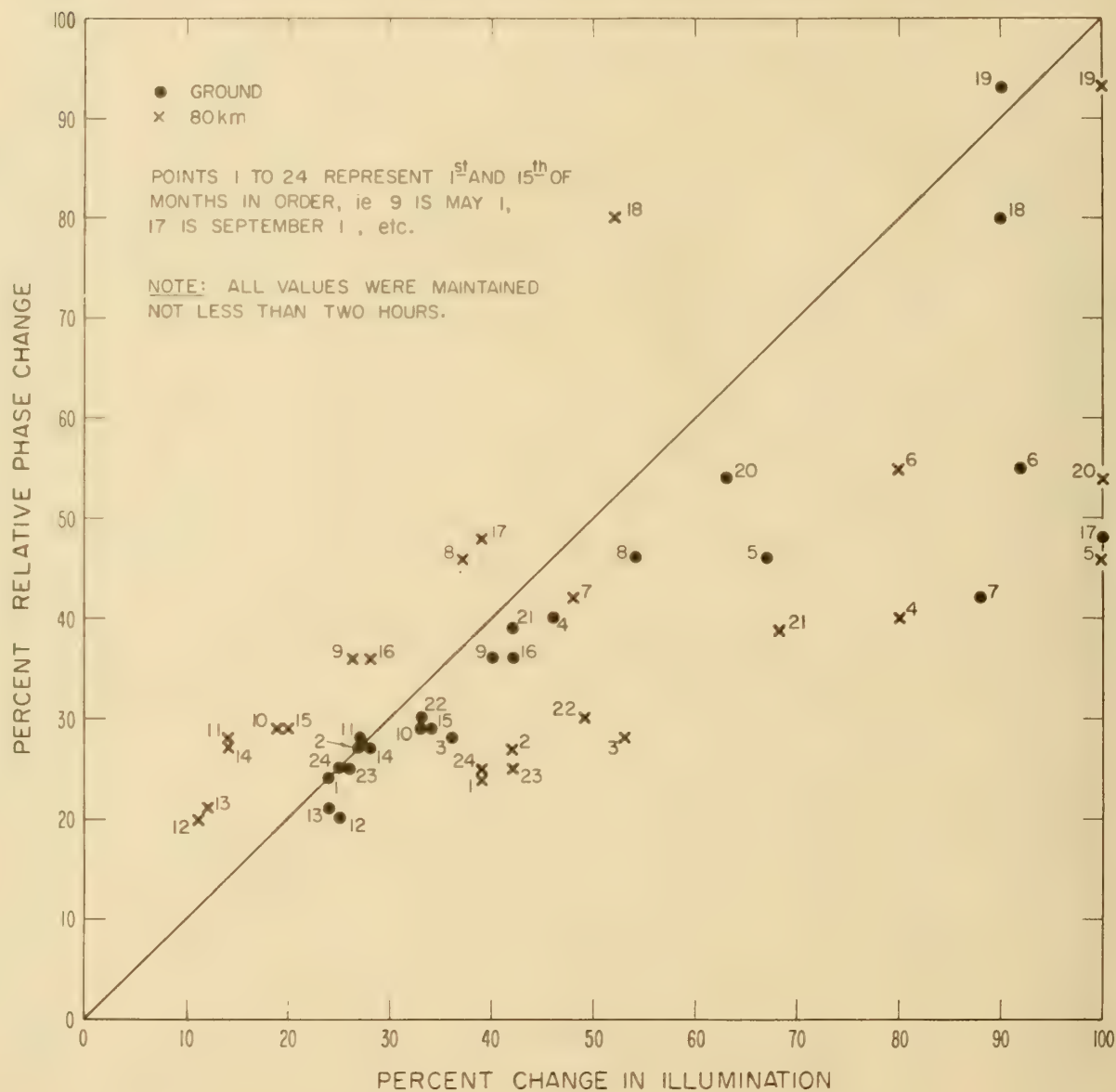


Figure 15. Mean diurnal phase change for 15 day intervals on GBR, Rugby to College, Alaska, path versus the corresponding diurnal change in path illumination.

Table 1

UT	MCNTHLY AVER	SDV	AVERAGE	ON PATH	1	2	FOR MONTH	1	1962
00	505.2	23.24	508.16	508.16	507.22	20.24	10.24	509.16	508.16
01	517.1	21.24	509.16	509.16	514.22	20.24	10.24	512.16	511.16
02	522.2	21.24	511.16	511.16	522.25	20.24	10.24	522.25	522.25
03	525.2	21.24	514.22	514.22	525.25	20.24	10.24	525.25	525.25
04	530.1	21.24	517.16	517.16	530.25	20.24	10.24	530.25	530.25
05	533.1	21.24	522.25	522.25	533.25	20.24	10.24	533.25	533.25
06	535.1	21.24	525.25	525.25	535.25	20.24	10.24	535.25	535.25
07	536.1	21.24	527.16	527.16	536.25	20.24	10.24	536.25	536.25
08	539.1	21.24	530.25	530.25	539.25	20.24	10.24	539.25	539.25
09	547.6	21.24	533.25	533.25	547.6	20.24	10.24	547.6	547.6
10	549.1	21.24	535.25	535.25	549.1	20.24	10.24	549.1	549.1
11	553.1	21.24	538.25	538.25	553.1	20.24	10.24	553.1	553.1
12	558.1	21.24	542.25	542.25	558.1	20.24	10.24	558.1	558.1
13	561.1	21.24	545.25	545.25	561.1	20.24	10.24	561.1	561.1
14	565.1	21.24	548.25	548.25	565.1	20.24	10.24	565.1	565.1
15	568.1	21.24	551.25	551.25	568.1	20.24	10.24	568.1	568.1
16	571.1	21.24	554.25	554.25	571.1	20.24	10.24	571.1	571.1
17	574.1	21.24	557.25	557.25	574.1	20.24	10.24	574.1	574.1
18	577.1	21.24	560.25	560.25	577.1	20.24	10.24	577.1	577.1
19	580.1	21.24	563.25	563.25	580.1	20.24	10.24	580.1	580.1
20	583.1	21.24	566.25	566.25	583.1	20.24	10.24	583.1	583.1
21	586.1	21.24	569.25	569.25	586.1	20.24	10.24	586.1	586.1
22	589.1	21.24	572.25	572.25	589.1	20.24	10.24	589.1	589.1
23	592.1	21.24	575.25	575.25	592.1	20.24	10.24	592.1	592.1

MONTHLY AVERAGE ON PATH 1 2 FOR MONTH 2 1962

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MONTHLY AVERAGE	ON PATH	1	2	3	FOR MONTH	3	1962
UT 00	NO	530	336	222	19	220	209
UT 01	NO	539	342	219	20	220	219
UT 02	NO	548	351	209	21	220	219
UT 03	NO	551	354	209	22	220	219
UT 04	NO	554	358	210	22	220	219
UT 05	NO	559	363	210	22	220	219
UT 06	NO	561	366	210	22	220	219
UT 07	NO	564	369	210	22	220	219
UT 08	NO	567	372	210	22	220	219
UT 09	NO	569	374	210	22	220	219
UT 10	NO	571	376	210	22	220	219
UT 11	NO	573	378	210	22	220	219
UT 12	NO	575	380	210	22	220	219
UT 13	NO	577	382	210	22	220	219
UT 14	NO	579	384	210	22	220	219
UT 15	NO	581	386	210	22	220	219
UT 16	NO	583	388	210	22	220	219
UT 17	NO	585	390	210	22	220	219
UT 18	NO	587	392	210	22	220	219
UT 19	NO	589	394	210	22	220	219
UT 20	NO	591	396	210	22	220	219
UT 21	NO	593	398	210	22	220	219
UT 22	NO	595	400	210	22	220	219
UT 23	NO	597	402	210	22	220	219
UT 24	NO	599	404	210	22	220	219
UT 25	NO	601	406	210	22	220	219
UT 26	NO	603	408	210	22	220	219
UT 27	NO	605	410	210	22	220	219
UT 28	NO	607	412	210	22	220	219
UT 29	NO	609	414	210	22	220	219
UT 30	NO	611	416	210	22	220	219
UT 31	NO	613	418	210	22	220	219
UT 32	NO	615	420	210	22	220	219
UT 33	NO	617	422	210	22	220	219
UT 34	NO	619	424	210	22	220	219
UT 35	NO	621	426	210	22	220	219
UT 36	NO	623	428	210	22	220	219
UT 37	NO	625	430	210	22	220	219
UT 38	NO	627	432	210	22	220	219
UT 39	NO	629	434	210	22	220	219
UT 40	NO	631	436	210	22	220	219
UT 41	NO	633	438	210	22	220	219
UT 42	NO	635	440	210	22	220	219
UT 43	NO	637	442	210	22	220	219
UT 44	NO	639	444	210	22	220	219
UT 45	NO	641	446	210	22	220	219
UT 46	NO	643	448	210	22	220	219
UT 47	NO	645	450	210	22	220	219
UT 48	NO	647	452	210	22	220	219
UT 49	NO	649	454	210	22	220	219
UT 50	NO	651	456	210	22	220	219
UT 51	NO	653	458	210	22	220	219
UT 52	NO	655	460	210	22	220	219
UT 53	NO	657	462	210	22	220	219
UT 54	NO	659	464	210	22	220	219
UT 55	NO	661	466	210	22	220	219
UT 56	NO	663	468	210	22	220	219
UT 57	NO	665	470	210	22	220	219
UT 58	NO	667	472	210	22	220	219
UT 59	NO	669	474	210	22	220	

Table 4

MONTHLY AVERAGE ON PATH 1 2 FOR MONTH 4 1962									
UT	SDV	QAV	NO	5 MIN	10 MIN	15 MIN	20 MIN	25 MIN	30 MIN
00	546.	551.	19	39.26	39.26	39.26	39.26	39.26	39.26
01	548.	555.	18	36.26	36.26	36.26	36.26	36.26	36.26
02	551.	559.	21	35.26	35.26	35.26	35.26	35.26	35.26
03	554.	569.	18	34.26	34.26	34.26	34.26	34.26	34.26
04	566.	569.	20	34.26	34.26	34.26	34.26	34.26	34.26
05	572.	574.	21	34.26	34.26	34.26	34.26	34.26	34.26
06	578.	572.	19	34.26	34.26	34.26	34.26	34.26	34.26
07	584.	585.	21	34.26	34.26	34.26	34.26	34.26	34.26
08	598.	592.	21	34.26	34.26	34.26	34.26	34.26	34.26
09	602.	602.	21	34.26	34.26	34.26	34.26	34.26	34.26
10	608.	605.	19	34.26	34.26	34.26	34.26	34.26	34.26
11	614.	605.	17	34.26	34.26	34.26	34.26	34.26	34.26
12	620.	606.	15	34.26	34.26	34.26	34.26	34.26	34.26
13	626.	608.	16	34.26	34.26	34.26	34.26	34.26	34.26
14	632.	612.	15	34.26	34.26	34.26	34.26	34.26	34.26
15	638.	608.	18	34.26	34.26	34.26	34.26	34.26	34.26
16	644.	608.	19	34.26	34.26	34.26	34.26	34.26	34.26
17	650.	608.	21	34.26	34.26	34.26	34.26	34.26	34.26
18	656.	608.	21	34.26	34.26	34.26	34.26	34.26	34.26
19	662.	608.	21	34.26	34.26	34.26	34.26	34.26	34.26
20	668.	608.	21	34.26	34.26	34.26	34.26	34.26	34.26
21	674.	608.	21	34.26	34.26	34.26	34.26	34.26	34.26
22	680.	608.	21	34.26	34.26	34.26	34.26	34.26	34.26
23	686.	608.	21	34.26	34.26	34.26	34.26	34.26	34.26

MONTHLY AVERAGE ON PATH 1 2 FOR MONTH 5 1962

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MONTHLY AVERAGE CN PATH 1 2 FOR MONTH 6 1962

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Table 7

MONTHLY AVERAGE				CN PATH				1 2 FOR MONTH				7 1962			
UT	AVR	SCV	NO	UAV	NC	NO	NO	+	5	MIN	MIN	MIN	MIN	MIN	MIN
00	561.	22.28	29	560.22	22	28	28	21.28	28	554.21	561.	21	562.	21	28
01	565.	20.28	28	564.23	23	28	28	19.28	28	565.22	566.	22	567.	22	28
02	565.	22.28	28	563.20	20	28	28	21.28	28	556.21	567.	21	568.	21	28
03	540.	22.28	28	537.23	23	28	28	21.28	28	556.22	567.	22	569.	22	28
04	519.	22.28	28	510.22	22	28	28	21.28	28	509.21	568.	21	570.	21	28
05	487.	16.28	28	489.22	22	28	28	14.28	28	487.23	569.	23	571.	23	28
06	484.	14.28	28	486.21	21	28	28	14.28	28	487.22	570.	22	572.	22	28
07	483.	14.28	28	486.19	19	28	28	14.28	28	487.21	571.	21	573.	21	28
08	485.	13.28	28	485.19	19	28	28	12.28	28	485.20	572.	20	574.	20	28
09	484.	11.28	28	485.18	18	28	28	11.28	28	485.19	573.	19	575.	19	28
10	482.	13.29	29	482.17	17	28	28	11.28	29	483.16	574.	16	576.	16	28
11	487.	15.29	29	483.21	21	29	29	11.28	29	483.20	575.	20	577.	20	28
12	486.	14.29	29	486.21	21	29	29	11.28	29	483.19	576.	19	578.	19	28
13	484.	12.29	29	485.20	20	29	29	10.29	29	483.18	577.	18	579.	18	28
14	486.	15.29	29	486.21	21	29	29	9.29	29	483.17	578.	17	580.	17	28
15	481.	3.48	8	482.4	4	8	8	4.28	8	483.2	579.	2	581.	2	8
16	483.	14.28	28	484.24	24	28	28	14.28	28	484.23	580.	23	582.	23	28
17	484.	16.27	27	484.22	22	27	27	15.27	27	484.21	581.	21	583.	21	28
18	484.	17.27	27	484.23	23	27	27	16.27	27	484.22	582.	22	584.	22	28
19	483.	17.27	27	483.23	23	27	27	16.27	27	483.22	583.	22	585.	22	28
20	485.	20.27	27	481.24	24	27	27	20.27	27	481.23	584.	23	586.	23	28
21	498.	19.28	28	487.27	27	28	28	19.28	28	487.26	585.	26	587.	26	28
22	524.	19.28	28	512.23	23	28	28	19.28	28	501.22	586.	22	588.	22	28
23	552.	15.26	26	529.18	18	26	26	15.26	26	523.17	587.	17	589.	17	26
	561.	17.28		554.20	20			17.28		550.19	588.	19	590.	19	

MONTHLY AVERAGE C.N. PATH 1 2 FCR MCNTF 8 1962

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MONTHLY AVERAGE CN PATH 1 2 FOR MCNTH 9 1962

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Table 10

MONTHLY AVERAGE UN PATH 1 2 FOR MONTH 10 1962

UT	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
AVER	534.	538.	548.	568.	579.	603.	606.	585.	525.	496.	457.	430.	432.	445.	471.	427.	412.	432.	457.	487.	508.	511.	525.	530.
SDV	35.	37.	37.	35.	37.	41.	37.	37.	32.	33.	36.	30.	38.	42.	31.	43.	39.	28.	32.	44.	50.	52.	52.	53.
ND	27	27	27	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
UN	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
PATH	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1 2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
FOR	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
MONTH	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
10	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1962	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

MONTHLY AVERAGE CN PATH 1 2 FOR MONTH 11 1962

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MONTHLY AVERAGE ON PATH 1 2 FOR MONTH 12 1962

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Table 13
Semi-monthly mean diurnal phase change
(GBR-College path)

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Dates													
1962 11-20	85	130	175	135	100	75	80	120	245	165	95	65	degrees
1962 25-5*	85	145	145	130	90	85	100	155	315	125	75	70	degrees

*Begins in month as shown to 5th of next month

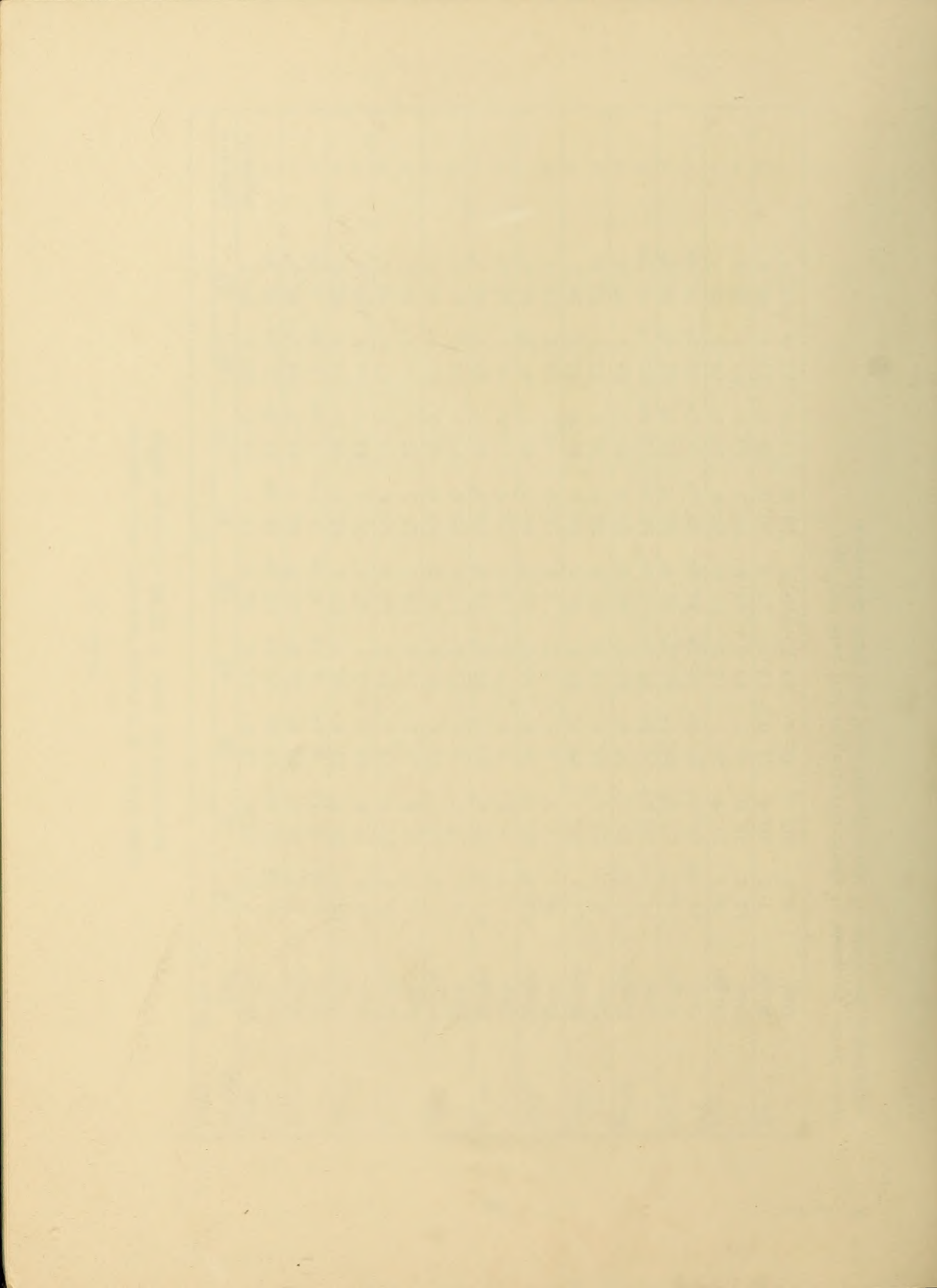
Table 14

RMS phase difference between observations
separated by time T (GBR-College path)

1962		T										
Month	Time of *	10	20	30	40	50	60	70	80	90	minutes degrees	
Jan.	Night	6.9	10.4	12.2	14.3	16.1	17.3	18.6	20.8	23.5		
"	Day	9.3*	11.8*	13.8*	17.8*	20.3*	24.0*	27.3*	31.4*	35.3*	"	
Feb.	Night	7.4 ^x	14.2 ^x	20.3 ^x	26.6 ^x	32.8 ^x	38.3 ^x	44.2 ^x	49.1 ^x	52.9 ^x	"	
"	Day	6.6*	7.3*	6.4*	8.2*	8.5*	7.7*	6.0*	7.3*	6.4*	"	
Mar.	Night	15.0	26.5	37.8	46.7	57.0	62.2	69.6	78.9	88.7	"	
"	Day	14.2	27.8	40.3	52.1	62.8	73.3	83.7	94.3	105.2	"	
Apr.	Night	11.5	20.0	27.6	35.6	43.3	50.5	57.2	63.8	70.6	"	
"	Day	7.2	11.8	15.2	19.4	23.1	25.3	27.6	30.5	33.6	"	
May	Night	11.2	19.3	25.4	30.8	36.1	40.4	44.0	46.9	48.4	"	
"	Day	4.7	6.7	9.1	11.5	13.4	15.8	18.1	20.9	23.3	"	
June	Night	13.3 ^x	22.4 ^x	30.3 ^x	35.3 ^x	39.4 ^x	43.4 ^x	46.9 ^x	48.7 ^x	54.7 ^x	"	
"	Day	5.7	5.8	7.8	7.8	9.2	8.5	10.4	10.3	11.0	"	
July	Night	13.5 ^x	22.5 ^x	30.4 ^x	36.8 ^x	41.3 ^x	44.7 ^x	47.7 ^x	47.5 ^x	51.6 ^x	"	
"	Day	4.2	5.7	6.5	7.2	7.9	8.5	9.2	10.2	10.7	"	
Aug.	Night	12.1	20.2	28.0	35.2	41.2	46.2	49.9	53.1	54.1	"	
"	Day	6.2	10.6	15.0	19.3	23.8	26.9	30.2	32.2	33.8	"	
Sept.	Night	12.4	23.1	33.6	44.3	54.8	64.4	73.5	81.5	87.4	"	
"	Day	14.7*	25.0*	36.8*	47.0*	56.6*	65.4*	74.0*	80.1*	90.1*	"	
Oct.	Night	14.6 ^x	27.0 ^x	35.7 ^x	43.0 ^x	50.9 ^x	55.7 ^x	59.7 ^x	62.4 ^x	66.8 ^x	"	
"	Day	14.4*	22.4*	25.8*	28.8*	34.2*	39.6*	44.2*	48.2*	51.9*	"	
Nov.	Night	8.2	11.9	15.1	18.2	21.2	22.8	23.6	24.9	26.3	"	
"	Day	12.2	22.0	31.7	41.0	48.8	57.3	63.7	71.2	76.2	"	
Dec.	Night	7.5	10.4	11.0	12.9	13.5	15.0	17.2	19.4	22.0	"	
"	Day	8.7	10.1	12.4	13.2	15.2	14.8	13.9	13.6	14.3	"	

*unreliable because of short duration of full path daylight

^xunreliable because of short duration of full path darkness



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